

circuits, or an interesting new topology **20**, the Stanley topology [9] shown in **Figure 8** can be used. The whole circuitry is placed inside a dewar exhibiting good thermal insulation walls, preferably using multi-layer vacuum insulation (MLI).

The motor drive circuitry if implemented in the topology of **Figure 8** consists of transistors, preferably MOSFETs, **21-24**, controlled by control drive circuits **25-28** and operated with pulse-width modulation (PWM). Commutating diodes **29-32** may be implemented with cryo-silicon or cryo-germanium devices. The latter have much lower on-state voltage. Inductors **34-38** could be implemented with high-temperature superconductors. Together with capacitors **39** and **40** they form a filter for the elimination of the pulse-width modulation frequency. Inductor **36** constitutes the windings of the motors. The MOSFETs **21-24** and diodes **29-32** can be implemented in the form of cryo-multi-chip modules providing miniaturization. This motor drive circuitry can have an electronic efficiency (without cooling penalty) of $> 99.7\%$.

I. Claims:

The following claims are made:

1. A cryogenic power conversion and conditioning system (CPC) using Cryo-MOSFETs or other cryo-semiconductor components is claimed
 - * for a fuel cell system designed for vehicles or other applications where the fuel cell receives its required hydrogen gas from a tank of liquid hydrogen at a cryogenic temperature of about 20 K thus providing automatically in a dual use function the cooling system for the CPC,
 - * or for a fuel cell system fed by natural gas (CH_4) via a reformer, stored in liquid form in a cryo-dewar, where the LNG dewar may or may not be inside another dewar filled with liquid nitrogen (LN_2), said cooling fluids being used for the cooling of the cryo-motor drives and HTS motors,
 - * which drives motors who may be implemented with high-temperature superconductor wires where said HTS motors are also cooled by said cooling fluids (LH_2 , LN_2 , LNG).
2. A cryogenic power conversion and conditioning circuitry (CPC) using Cryo-MOSFETs is claimed for a fuel cell system where the power electronic circuitry is cooled by being placed into the temperature gradient environment between 20 K and 200 K for cryogenic cooling if LH_2 is used.
3. A cryogenic power conversion and conditioning circuit (CPC) using Cryo-MOSFETs and fed by a fuel cell system is claimed which is housed in a hermetically sealed container immersed in the cryo-cooled environment of a liquid natural gas tank.
4. A cryogenic power conversion and conditioning system (CPC) using Cryo-MOSFETs is claimed for a vehicle fuel cell system which is smaller, has lower weight and is less costly than conventional systems.
5. A cryogenic power conversion and conditioning system (CPC) using Cryo-MOSFETs is claimed for a fuel cell system where the CPC circuitry is conduction cooled by cool fingers

connected to the LH2 or LNG tanks.

6. A power conditioning system is claimed for fuel cells fed by uncooled fuels where the whole power electronics, i.e. motor drives and HTS motors, is cryogenically cooled in order to achieve high efficiency, ultra-small size, ultra-low weight and low cost.
7. A system according to claim 1 is claimed where high-temperature superconductor cables are used for power transmission as well as supply of cooling fluid such as LN2 making use of the "load shedding" property of LN2.
8. A cryogenic power conditioning system according to claim 1 is claimed where in the case of liquid nitrogen use the fuel cell efficiency is increased by also using liquid oxygen produced together with the LN2 eliminating the need to pressurize the oxygen used in the fuel cell.
9. A cryogenic power conditioning system is claimed
 - * which uses cryocooled semiconductor switches such as cryo-MOSFETs, cryo-IGBTs as active devices and silicon or germanium cryo-diodes for commutation in a half-bridge, full-bridge, three-phase or Stanley topology, preferably using optical coupling to the gate control terminals,
 - * where the cryo-MOSFETs, cryo-IGBTs and cryo-diodes are implemented in the form of Cryo-Multi-Chip Modules (CMCM) providing small size and low weight which is especially important for all transportation systems,
 - * where the driver circuits are implemented by cryo-cooled integrated circuits,
 - * where the necessary filter inductors and power busses of the inverters are implemented with high-temperature superconductors.
10. A CPC system is claimed where the cryo-fuels are also used to cool a cryo-light system based on high-efficiency cryo-light-emitting diodes (LEDs).

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- M7 O. Mueller, "The cryogenic power MOSFET," *Proceedings of the 20th International Power Conversion Conference*, München, Germany, June 25-29, 1990 (Also GE CRD Report 90CRD206)
- M8 O. Mueller, "Switching losses of the cryogenic MOSFET and SIT," *Cryogenics*, vol. 30, pp. 1094-1100, December 1990 (Also an oral paper at the *International Conference on Low Temperature Electronics*, Berkeley, CA, April 23-26, 1990)
- M9 O. Mueller and W.A. Edelstein, "The cryogenic NMR RF power amplifier," *Society of Magnetic Resonance in Medicine (SMRM)*, 9th Annual Meeting, New York, NY, Book of Abstract, p. 205, August 18-24, 1990
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